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in series other than power series; partial differentiation, especially of composite functions. [For example, a clear understanding of the expression

$$\frac{du}{dx}=\frac{\partial u}{\partial x}+\frac{\partial u}{\partial z}\cdot\frac{\partial z}{\partial x},$$

where $u = f(x, y, z)$ and $z = \varphi(x, y)$.] Line integrals, with Stokes's theorem, vector analysis.

D. CONCLUSIONS.

During the general discussion the speakers modified slightly their choices of material. The following was practically agreed upon as the basis for a course suitable for all three classes of students and follows very nearly the material common to the three original selections. The order here given is not to be considered as indicating necessarily the best order of presentation: Systems of linear equations, determinants and elimination, graphical representation of polynomials, transformations of equations, solutions of the cubic and biquadratic, methods of locating and approximating roots of numerical equations—Descartes's rule of signs, Sturm's theorem, multiple roots, Horner's method of approximation, Newton's method of approximation (if only one method of approximation is given, Newton's is to be preferred), fundamental theorem of algebra and its corollaries, symmetric functions of the roots of an equation, permutations and combinations, problems involving pure number-relations.

The subject-matter above suggested would furnish about enough material for a three-hour course during one semester.

A LIST OF MATHEMATICAL BOOKS FOR SCHOOLS AND COLLEGES.[1]

Preliminary Statement. The following list contains the titles of 160 books which it is believed are suitable for purchase by the usual school or college library.[2] The plan has been carried out of forming the books into four divisions of 40 each, corresponding roughly to the mathematical attainments of the freshman, sophomore, junior and senior years, this arrangement also indicating incidentally the relative difficulty which the books present. Preference has been given throughout to books in the English language, and no text-books have been included except a few having a well-recognized value as books of reference. As it might be desirable for a school or college to know in advance the price of a book which it wished to buy, an effort has been made to ascertain the present selling price and indicate it in each case, but this has not been possible in all cases owing to the uncertainty now existing in this matter, especially as regards books published by foreign houses.

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[1] Reference may be made to a similar list, but intended more especially for high schools and normal schools, which has recently been published under the auspices of the Teachers College, Columbia University, New York. The title is "A brief list of mathematical books suitable for libraries in high schools and normal schools," *Teachers College Bulletin*, Series 8, No. 3 (1916).

[2] The Library Committee was appointed at the Cambridge meeting of the Association in September, 1916, and a preliminary report was made at the New York meeting in December, 1916. (See the February MONTHLY, page 58.) Of the numerous tentative plans mentioned in this report, the following pages give the results of several months' work of the committee on the one considered of first importance. EDITORS.

Needless to say, the list contains but a few of the possible books which might appropriately be recommended for the purpose in hand. It is hoped, however, that it indicates what may well constitute a nucleus for the college library.

THE LIBRARY COMMITTEE OF THE ASSOCIATION.

FLORIAN CAJORI, Colorado College.
E. S. CRAWLEY, University of Pennsylvania.
SOLOMON LEFSCHETZ, University of Kansas.
W. R. LONGLEY, Yale University.
R. E. ROOT, U. S. Naval Academy.
W. B. FORD, University of Michigan, *Chairman*.

BOOKS FOR FRESHMEN.

Algebra.

1. FINE (H. B.). The number-system of algebra treated theoretically and historically. Heath. $1.00.
   Admirable introduction to the critical study of algebra.
2. HALL (H. S.) and KNIGHT (S. R.). Higher algebra. Macmillan.
   Gives the technique of a wide variety of topics, with numerous examples.
3. MARSH (H. W.). Technical algebra. Wiley. $2.00.
   Shows the uses of algebra in industry.
4. SMITH (C.). A treatise on algebra. Macmillan.
   Good as a text and as a reference book. Should be in all libraries.

Geometry.

5. CASEY (J.). Sequel to Euclid. Longmans. $1.10.
   Amplifies the ordinary high school course in geometry.
6. GODFREY (C.) and SIDDONS (A. W.). Modern geometry. Cambridge University Press.
   Continues geometry in an interesting way beyond Euclid.
7. HALSTED (G. B.). Rational geometry. Wiley. $1.50.
   Considers the logical foundations of geometry.
8. MARSH (H. W.). Technical geometry. Wiley. $1.25.
   Shows the uses of geometry in modern industry.

Trigonometry and Surveying.

9. HOBSON (E. W.). Treatise on plane trigonometry. Cambridge University Press. $3.00.
   An extensive and thorough treatment of the theoretical side of trigonometry.
10. MARSH (H. W.). Technical trigonometry. Wiley. $1.50.
    Shows uses of trigonometry in industry.
11. TRACEY (J. C.). Plane surveying. Wiley. $3.00.
    Valuable both as text and field manual.

History.

12. BALL (W. W. R.). Primer of the history of mathematics. Macmillan. $0.90.
    Valuable summary of the principal events in the history of mathematics.

13. Cajori (F.). History of elementary mathematics. Second edition. Macmillan, 1917. $1.75.
    A careful work, interestingly written.
14. Hill (G. F.). The development of Arabic numerals in Europe. Oxford Press. $1.75.
15. Smith (D. E.) and Karpinski (L. C.). The Hindu-Arabic numerals. Ginn. $2.00.
    Scholarly presentation of the theories as to the origin of our numerals.

Miscellaneous.

16. Andrews (W. S.). Magic squares and cubes. Open Court Publishing Co. $1.50.
    One of the few treatments of this subject in English.
17. Ball (W. W. R.). Mathematical recreations. Macmillan. $3.50.
    Entertaining and instructive.
18. Breckenridge (W. E.), Mersereau (S. F.) and Moore (C. F.). Shop problems in mathematics. Ginn. $1.00.
    Excellent collection of applied problems in elementary mathematics.
19. Brinton (W. C.). Graphic methods for presenting facts. Engineering News Co. $4.00.
    Describes general uses of the graphic method.
20. Compton (A. G.). Manual of logarithmic computation. Wiley. $1.50.
21. Cracknell (A. G.). Practical mathematics. Longmans. $1.10.
    Gives many well-graded, illustrative problems.
22. Duncan (R. H.). Practical curve tracing. Longmans. $1.60.
23. Dunlop (H. C.) and Jackson (C. S.). Slide rule notes. Longmans. $0.75.
24. Faber (A. W.). Instructions for calculating rule. Faber, Newark, N. Y.
    A good manual on the slide rule.
25. Gephart (W. F.). Principles of insurance. Macmillan. 2 vols. $1.60 each.
    Elements of the mathematical aspects of insurance.
26. Henrici (O. F. M. E.). Congruent figures. Longmans. $0.50.
    Amplifies high-school geometry.
27. Hinton (C. H.). The fourth dimension. Sonnenschein, London.
    Interesting treatment of this popular subject.
28. Horsburgh (E. M.). Handbook of the exhibition of Napier relics and of books, instruments, and devices for facilitating calculation. The Royal Society of Edinburgh.
29. Johnson (J. F.). Practical shop mechanics and mathematics. Wiley. $1.00.
30. Koch (E. H.). The mathematics of applied electricity. Wiley. $3.00.
31. Lagrange (J. L.). Lectures on elementary mathematics. Open Court Publishing Co. $1.00.
    The reprint of a notable work written a century ago by a great mathematician.
32. Manning (H. P.). Fourth dimension simply explained. Munn and Co., N. Y. $1.50.
    A collection of essays on this popular subject.
33. Marsh (H. W.). Industrial mathematics. Wiley. $2.00.

34. Row (T. S.). Geometric paper folding. Edited by Beman and Smith. Open Court Publishing Co. $1.00.
Gives interesting side light on the ordinary construction problems of plane geometry.
35. Sanborne (F. B.). Mechanics problems. Engineering News Co.
One of the best collections of problems in elementary mechanics.
36. Saxelby (F. M.). Course in practical mathematics. Longmans. $2.25.
37. Schubert (H.). Mathematical recreations. Open Court Publishing Co. $0.75.
38. Weld (L. G.). A short course in the theory of determinants. Macmillan. $1.90.
39. White (W. F.). Scrap-book of elementary mathematics. Open Court Publishing Co. $1.00.
40. Whitworth (W. W.). Choice and Chance. Deighton, Bell and Co., London.
Elementary treatment of this interesting subject, with numerous examples.

Books for Sophomores.

Analytical Geometry.

1. Salmon (G.). Conic sections. Longmans. $3.75.
2. Smith (C.). An elementary treatise on conic sections. Macmillan. $1.40.
3. Smith (C.). An elementary treatise on solid geometry. Macmillan. $3.25.

Calculus.

4. Byerly (W. E.) Differential calculus. Ginn. $2.00.
5. Byerly (W. E.). Integral calculus. Ginn. $2.00.
6. Lamb (H.). An elementary course of infinitesimal calculus. Cambridge University Press. $3.00.
7. Leib (D. D.). Problems in the calculus. Ginn. $1.00.
8. Osgood (W. F.). A first course in the differential and integral calculus. Macmillan. $2.00.
9. Peirce (B. O.). A short table of integrals. Ginn. $1.00.
10. Perry (J.). Calculus for engineers. Arnold. London.

Projective Geometry.

11. Cremona (L.). Elements of projective geometry. Translation by Leudesdorf. Oxford Clarendon Press.
12. Emch (A.). Introduction to projective geometry and its applications. Wiley. $2.50.
13. Hatton (J. L. S.). The principles of projective geometry. Cambridge University Press.
14. Mathews (G. B.). Projective geometry. Longmans.

History.

15. Ball (W. W. R.). A short history of mathematics. Macmillan. $3.00.
16. Cajori (F.). History of mathematics. Macmillan. Second edition in press.

17. Fink (C.). A brief history of mathematics. Translated by Beman and Smith. Open Court Pub. Co. $1.50.
18. Smith (D. E.). History of modern mathematics. Wiley. $1.00.

Miscellaneous.

19. Bruhns. A new manual of logarithms to seven places of decimals. Lemcke and Buechner, New York. (1913.)
    Very complete.
20. Cobb (H. E.). Elements of applied mathematics. Ginn. $1.00.
21. Coolidge (J. L.). The elements of non-euclidian geometry. Oxford. Clarendon Press.
22. Dickson (L. E.). Elementary theory of equations. Wiley. $1.75.
23. De Morgan (A.). Elementary illustrations of the differential and integral calculus. Open Court Pub. Co. $1.00.
34. De Morgan (A.). A budget of paradoxes. Revised by D. E. Smith. Open Court Pub. Co. 2 Vols. $7.00.
35. Dupuis (N. F.). Elements of synthetic solid geometry. Macmillan. $1.60.
36. Fischer (A.). The mathematical theory of probabilities and its application to frequency curves and statistical methods. Macmillan. $2.00.
27. Klein (F.). Famous problems in elementary geometry. Translated by Beman and Smith. Ginn. $0.50.
28. MacFarlane (A.). Ten British mathematicians of the nineteenth century. Wiley. $1.25.
29. Manning (H. P.). Geometry of four dimensions. Macmillan. $2.00.
30. Mellor (J. W.). Higher mathematics for students of chemistry and physics. Longmans. $4.50.
31. Minchin (G. M.) and Dale (J. B.). Mathematical drawing. Arnold. London.
32. Moritz (R. E.). Memorabilia mathematica. Macmillan. $3.00.
    Contains quotations from the writings of prominent mathematicians and anecdotes about them.
33. Schultze (A.). The teaching of mathematics in secondary schools. Macmillan. $1.25.
34. Skinner (E. B.). Mathematical theory of investment. Ginn. $2.25.
35. Smith (C.). A treatise on algebra. Macmillan.
36. Smith (D. E.). The teaching of elementary mathematics. Macmillan. $1.00.
37. Smith (D. E.). The teaching of geometry. Ginn. $1.25.
38. Turner (G. C.). Graphical methods in applied mathematics. Macmillan. $1.50.
39. Weld (L. D.). Theory of errors and least squares. Macmillan. $1.25.
40. Wolstenholme (J.). Mathematical problems on subjects for the mathematical tripos examinations. 2,814 problems. Macmillan. 18 shillings.

BOOKS FOR JUNIORS.

Geometry.

1. DURELL (C. V.). A course of plane geometry for advanced students. 2 Vols. Macmillan. Vol. I, $1.50. Vol. II, $2.00.
2. HEATH (T. L.). The thirteen books of Euclid's elements. Cambridge University Press. 3 Vols. $13.50.
3. HILBERT (D.). The foundations of geometry. Translation by TOWNSEND. Open Court Pub. Co. $1.00.
4. LOBACHESVKI (N. I.). Theory of parallels. Translation by HALSTED. Open Court Pub. Co. $1.25.
5. MILNE (J. J.). Homogeneous coördinates. Cambridge University Press.
6. MILNE (J. J.). Elementary treatise on cross-ratio geometry, with historical notes. Cambridge University Press.
7. SCOTT (C. A.). Modern analytic geometry. Macmillan.
   Now out of print, but procurable from second-hand book stores.
8. SALMON (G.). Analytic geometry of three dimensions. Revised by R. A. P. ROGERS. Longmans. Vol. I (1912) $3.00. Vol. II (1915) $2.25.
9. SNYDER (V.) and SISAM (C. H.). Analytic geometry of space. Holt. $2.50.

Algebra.

10. BÔCHER (M.). Introduction to higher algebra. Macmillan. $1.90.
11. BURNSIDE (W. S.) and PANTON (A. W.). Theory of equations. Longmans. Vol. I $3.00. Vol. II $3.00.
12. CHRYSTAL (G.). Textbook in algebra. 2 vols. Macmillan. $9.00.
13. FINE (H. B.). A college algebra. Ginn. $1.50.

Calculus and Differential Equations.

14. BYERLY (W. E.). Problems in differential calculus. Ginn. $0.75.
15. COHEN (A.). Differential equations. Heath. $2.00.
16. HEDRICK (E. R.) and KELLOGG (O. D.). Applications of the calculus to mechanics. Ginn. $1.25.
17. JOHNSON (W. W.). A treatise on ordinary and partial differential equations. Wiley. $3.50.
18. MURRAY (D. A.). Differential equations. Longmans. $1.90.
19. WILLIAMSON (B.). A treatise on the differential calculus. Appleton.
20. WILLIAMSON (B.). A treatise on the integral calculus. Appleton.

Miscellaneous.

21. BOOLE (G.). Finite differences. Macmillan.
    Out of print, but procurable from second-hand book stores.
22. CARMICHAEL (R. D.). Theory of numbers. Wiley. $1.00.
23. COFFIN (J. G.). Vector analysis. Wiley. $2.50.
24. DIXON (A. C.). Elementary properties of elliptic functions. Macmillan.

25. Enriques (F.). Problems of science. Translation by Royce. Open Court Pub. Co. $2.50.
26. Frankland (W. B.). Theories of parallelism. Cambridge University Press. $0.90.
27. Greenhill (A. G.). The applications of elliptic functions. Macmillan.
28. Hancock (H.). Elliptic integrals. Wiley. $1.25. 1917.
29. Kelland (P.) and Tait (P. G.). Dynamics of a particle. Macmillan.
30. Merriman (M.) and Woodward (R. S.). Higher mathematics. Wiley. Five parts. $0.75 each.
31. Miller (G. A.). Historical introduction to mathematical literature. Macmillan. $1.60. 1917.
32. Miller (J. A.) and Lilly (S. B.). Analytic mechanics. Heath. $2.00.
33. Perry (J.). The teaching of mathematics. Macmillan. $0.75.
34. Russel (B.). Foundations of geometry. Cambridge University Press. $2.00.
35. Sommerville (D. M. Y.). Elements of non-euclidean geometry. Bell. London.
36. Williamson (B.). A treatise on dynamics. Appleton.
37. Withers (J. W.). Euclid's parallel postulate. Open Court Pub. Co. $1.25.
38. Young (J. W.). Fundamental concepts of algebra and geometry. Macmillan. $1.60.
39. Young (J. W. A.). Monographs on topics of modern mathematics. Longmans. $3.00.
40. Ziwet (A.) and Field (P. F.). Introduction to analytical mechanics. Macmillan. $1.60.

Books for Seniors and First Year Graduates.

1. Basset (A. B.). Elementary treatise on cubic and quartic curves. Deighton, Bell and Co. Cambridge.
2. Bromwich (T. J. I.). Theory of infinite series. Macmillan. $4.75.
3. Burkhardt (H.). Theory of functions of a complex variable. Translation by Rasor (S. E.). Heath. $4.00.
4. Byerly (W. E.). Harmonic functions. Wiley. $1.00.
5. Byerly (W. E.). Fourier Series. Ginn. $3.00.
6. Cantor (G.). Contributions to the founding of the theory of transfinite numbers. Translation by Jourdain. Open Court Pub. Co. $1.25.
7. Carmichael (R. D.). Diophantine analysis. Wiley. $1.25.
8. Cohen (A.). The Lie theory of one parameter groups. Heath.
9. Couturat (L.). Algebra of logic. Translation by Robinson. Open Court Pub. Co. $1.50.
10. Dedekind (R.). On the nature and meaning of numbers. Translation by Beman. Open Court Pub. Co. $0.75.
11. De Morgan (A.). On the study and difficulties of mathematics. Open Court Pub. Co. $0.75.
12. Dickson (L. E.). Algebraic invariants. $1.25.

13. Eisenhart (L. P.). A treatise on the differential geometry of curves and surfaces. Ginn. $4.50.
14. Fiske (T. S.). Functions of a complex variable. Wiley. $1.00.
15. Forsyth (A. R.). Differential equations. Macmillan.
16. Glenn (O. E.). The theory of invariants. Ginn. $2.75.
17. Goursat (E.). Course in mathematical analysis. Translation by Hedrick (E. R.). Ginn. Vol. I. $4.00. Vol. II, two parts, $2.75 each.
18. Hobson (E. W.). The theory of functions of a real variable. Cambridge University Press.
19. Huntington (E. V.). The continuum and other types of serial order. Second edition. Harvard University Press.
20. Ingersoll (L. R.) and Zobel (O. J.). Introduction to the mathematical theory of heat conduction. Ginn. $1.60.
21. Mathews (G. B.). Theory of numbers—Part I. Cambridge University Press. $3.50.
22. Miller (G. A.), Blichfeldt (H. F.) and Dickson (L. E.). Theory and applications of finite groups. Wiley. $4.00.
23. Loney (S. L.). An elementary treatise on the dynamics of a particle and of rigid bodies. Cambridge University Press. G. P. Putnam's Sons. $4.00.
24. Osgood (W. F.). Introduction to infinite series. Harvard coöperative society. Cambridge, Mass. $0.75.
25. Peirce (B. O.). Newtonian potential function. Ginn. $2.50.
26. Pierpont (J.). Theory of functions of real variables. Ginn. Vol. I, $4.50. Vol. II, $5.00.
27. Poincaré (H.). Science and hypothesis. Translated by Halsted. The Science Press, New York.
28. Reid (L. W.). Elements of the theory of algebraic numbers. Macmillan. $3.50.
29. Serret (J. A.). Cours de calcul différential et intégral. Paris, Gauthier-Villars.
30. Tannery (J.). Introduction à la théorie des fonctions d'une variable. Paris. Hermann.
31. Townsend (E. J.). Functions of a complex variable. Holt. $4.00.
32. Veblen (O.) and Lennes (N. J.). Introduction to infinitesimal analysis. Wiley. $2.00.
33. Veblen (O.) and Young (J. W.). Projective geometry. Vol. I. Ginn. $4.00.
34. Wertheim (G.). Elemente der Zahlentheorie. Leipzig. Teubner.
35. Whitehead (A. N.). The axioms of projective geometry. Cambridge University Press.
36. Whitehead (A. N.) An introduction to mathematics. Holt. $0.50.
37. Wilson (E. B.). Advanced calculus. Ginn. $5.00.
38. Young (J. W. A.). Teaching of mathematics. Longmans. $1.50.

39. ZIZEK (F.). Statistical averages. Translation by PERSONS. Holt. $2.50.
40. ZORETTI (L.). Leçons de mathématiques générales. Paris. Gauthier-Villars.

THE DOUBLE POINTS OF RATIONAL CURVES.

By OSCAR J. PETERSON, University of Wisconsin.

Let P be a point whose homogeneous coördinates are given by the parametric equations:

$$
\begin{aligned}
\theta x &= f(\lambda) \equiv a_0\lambda^n + a_1\lambda^{n-1} + \cdots + a_n, \\
\theta y &= g(\lambda) \equiv b_0\lambda^n + b_1\lambda^{n-1} + \cdots + b_n, \\
\theta z &= h(\lambda) \equiv c_0\lambda^n + c_1\lambda^{n-1} + \cdots + c_n,
\end{aligned}
\tag{1}
$$

where $f(\lambda)$, $g(\lambda)$, $h(\lambda)$ have no common factor. If λ be made to vary continuously from $-\infty$ to $+\infty$, the point P will describe a continuous curve of order n. Such a curve is said to be *rational* or *unicursal.*

If two distinct values s, t of the parameter λ give the same set of coördinates, so that both determine the same point $P_{s,t}$, this point is a *double point,* or singular point of the curve. For these values s, t we have

$$f(s) : g(s) : h(s) = f(t) : g(t) : h(t),$$

or

$$
\begin{aligned}
g(s)h(t) - h(s)g(t) &= 0, \\
h(s)f(t) - f(s)h(t) &= 0, \\
f(s)g(t) - g(s)f(t) &= 0.
\end{aligned}
$$

Each of these equations is divisible by $s - t$, since it is zero for $s = t$. After division by $s - t$ let

$$
\begin{aligned}
F(s, t) &\equiv \frac{g(s)h(t) - h(s)g(t)}{s - t} = 0, \\
G(s, t) &\equiv \frac{h(s)f(t) - f(s)h(t)}{s - t} = 0, \\
H(s, t) &\equiv \frac{f(s)g(t) - g(s)f(t)}{s - t} = 0
\end{aligned}
\tag{2}
$$

be the equations. Each pair of values (s, t) which is a solution of the system of equations (2) determines a double point; and, conversely, corresponding to any double point of the curve is a pair of values (s, t) which satisfies equations (2).

(*a*) If $s \neq t$, the curve crosses itself; $P_{s,t}$ is a *node,* or *crunode.*

(*b*) If s and t are conjugate imaginaries, and the point $P_{s,t}$ is real, then $P_{s,t}$